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AN EVALUATION OF BRUCE NGS 'A' UNIT 2 BOILER ROOM AIR INLEAKAGE USING TRACER GAS TECHNIQUES

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ABSTRACT

High tracer gas concentrations were measured in the boiler rooms during the 1987 Bruce NGS 'A' outage and pressure test. An ethylene tracer gas inleakage experiment was therefore performed on the Bruce NGS 'A' Unit 2 boiler rooms on April 30, 1989 to quantify the leakage rate. The test was carried out with containment at a relatively constant pressure of -14 kPa(g). Ethylene tracer gas samples were collected simultaneously in the boiler rooms and containment over a three hour period. From the concentrations measured in the grab samples the leakage rate from the two boiler rooms into containment at -14 kPa(g) was estimated to be about 0.9% of the boiler room volume per hour. This leak rate corresponds to only about 2.8% of the overall leak rate for all of Bruce NGS 'A' containment. The Unit 2 boiler rooms are not significant contributors to the overall leak rate of the station. The boiler room repair work performed as a result of the leak search during the 1987 outage was effectively done.

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1.0 INTRODUCTION

During the May, 1987 Bruce NGS 'A' outage, the containment pressure test and the corresponding leak search revealed high ethylene tracer gas concentrations in the boiler rooms, particularly those of Unit 2. During the outage, the ventilation to the boiler rooms was periodically operated through the confinement dryers to reduce tritium levels. However, the ethylene concentration remained significant, a further sign of the presence of leaks/1/.

As a result of the boiler room findings, NGD recommended to the Bruce NGS 'A' Technical Section that an inleakage experiment on the Unit 2 boiler rooms be undertaken. The success of this experiment was contingent on the ethylene concentration in containment being low enough to allow the measurement of any increase due to inleakage from the boiler rooms.

The reactor vault system at Ontario Hydro's stations is maintained at approximately 2.5 kPa (0.36 psig) below atmospheric pressure during normal operation, in order to reduce dispersion of contamination. During each operating quarter a negative leak rate test is performed on the containment structure at -17 kPa(g) (-2.47 psig). The inleakage test described in this report was done during a quarterly leak rate test with the pressure in the containment structure maintained at about -14 kPa(g) (-2.03 psig).

The inleakage test was completed on Bruce NGS 'A' Unit 2 boiler rooms on April 30, 1989. This report presents the experimental details in Section 2.0, the results and discussion in Section 3.0 and conclusions and recommendations in Section 4.0.

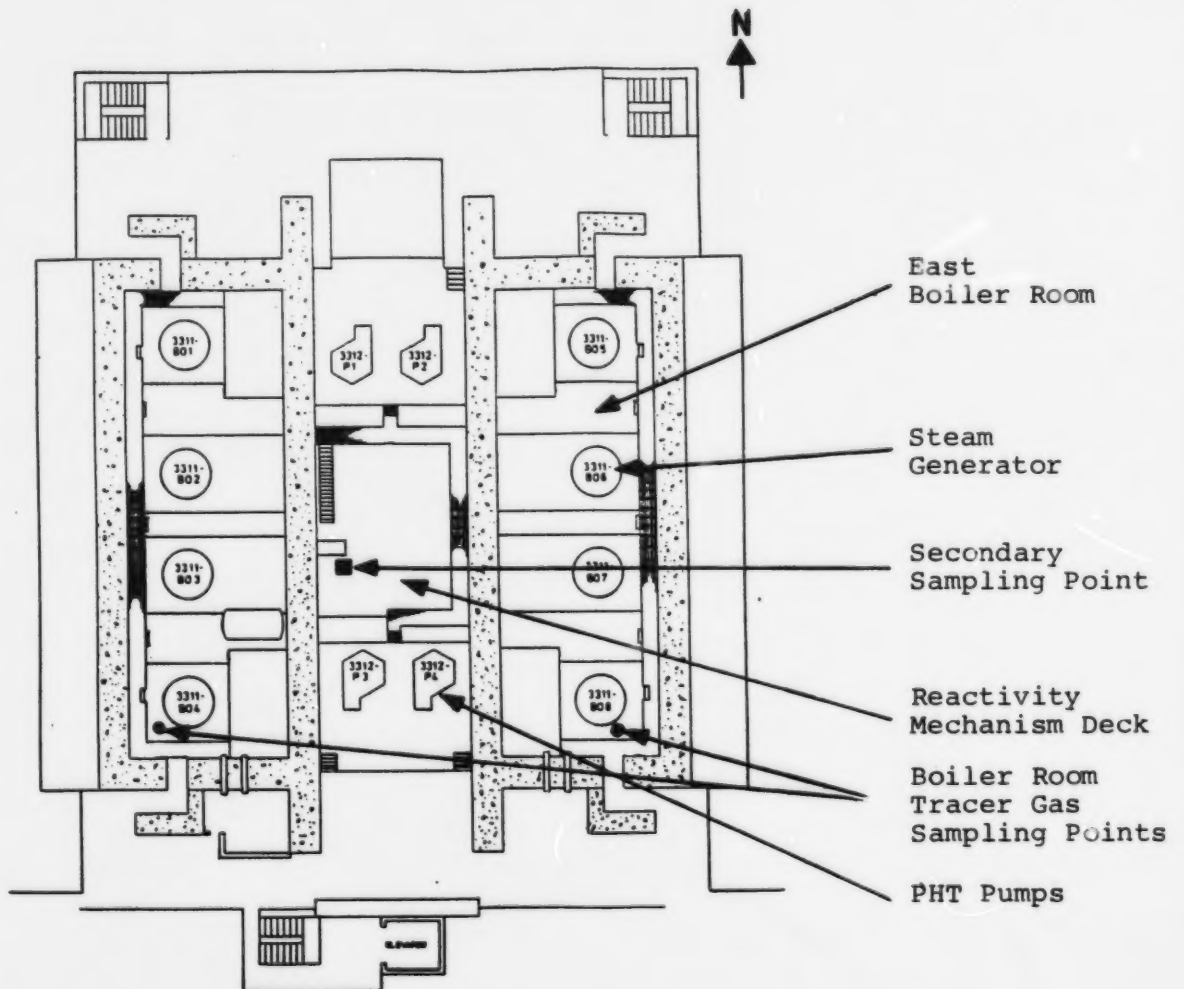
2.0 EXPERIMENTAL

2.1 Site Description

The East and West boiler rooms of Bruce NGS 'A' Unit 2 were the sites for the inleakage experiment (Figure 1). Access to the two boiler rooms was restricted because of high tritium backgrounds. As a result remote sampling systems were designed and installed. Each boiler room has two separate ventilation systems on level 693'. During the test, the north system on each boiler was shut down and each south unit was used to inject the ethylene tracer gas into the respective boiler rooms. The dynamic mode of injection allowed the tracer to be well mixed in the boiler rooms and to be maintained at a steady concentration.

FIGURE 1

BRUCE NGS 'A' UNIT 2 BOILER ROOMS
ELEVATION 678' - TRACER GAS SAMPLING POINTS



Two sampling locations were used, one on elevation 678' on the reactivity mechanism deck between the heat transport pumps (Figure 1) and the other on elevation 615' at EP-1057. The latter is a direct penetration into containment while the upper level one is a secondary penetration into containment through systems on the reactivity mechanism deck.

2.2 Sample Collection

All gas samples were collected in Tedlar bags (3.0 L) at specific time intervals during the test. A sampling system was set up at each of the four locations to be monitored. Figure 2 describes the gas sampling system used. The valve (V2) on the return line to the boiler room or containment was opened and the pump turned on to allow the lines to be flushed continually. When a sample was due to be taken, a Tedlar bag was attached to the sampling probe on the 'Tee' through a plastic interconnect; the Dura-clamp, used to seal the Tygon tubing that is attached to the bag, was opened; the sampling line shut off valve (V1) was opened and the valve on the return line (V2) was closed down until the bag began to fill. When the bag was nearly full the sampling valve (V1) was closed and at the same time the valve on the return line (V2) was opened; the Dura-clamp on the inlet line to the bag was closed; the sample bag was removed from the sampling system and labelled with location and time of sample. This sampling procedure was repeated for each air sample taken at each of the sampling sites.

2.3 Ethylene Tracer Gas Analysis

The ethylene tracer gas in each of the grab air samples collected during the inleakage test was quantified by gas chromatography utilizing calibrated photoionization detectors (PHOTOVAC Model 10S50 and 10S30 systems). The actual ethylene tracer gas concentrations were determined by interpolation from calibration curves that were determined for each detector. The calibration curves were developed using ethylene in air calibration gases (1 ppm and 99.5 ppm) obtained from Matheson as primary standards with a quoted concentration tolerance of $\pm 1\%$. Additional concentrations were generated using a dynamic dilution system described in an earlier report/2/. The calibration gas samples were blown into Tedlar bags and the ethylene concentrations measured in the same manner as for the field samples. The accuracy of the concentrations generated by the dynamic dilution system was about $\pm 2\%$.

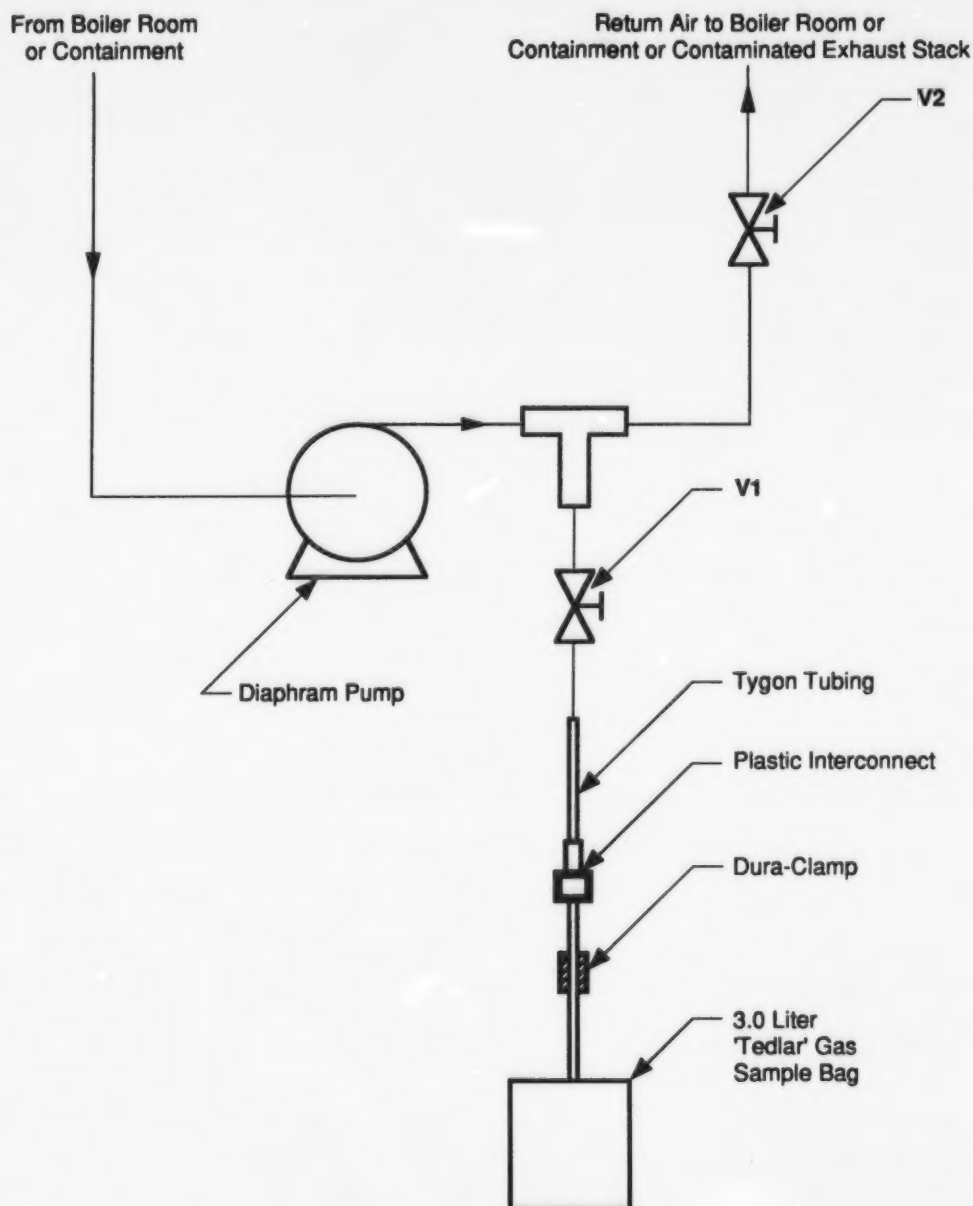


FIGURE 2
TRACER GAS SAMPLING SYSTEM
USED AT ALL LOCATIONS

3.0 RESULTS AND DISCUSSION

A total of 64 tracer gas samples were collected over the 3-h test period on April 30, 1989. The results are listed in Table I and shown in Figures 3 and 4. Originally, the test plan called for two containment sampling points to follow the rate of tracer gas increase in containment with time. However, the secondary penetration located on the reactivity mechanism deck could not be used as the air samples had to be drawn through a diaphragm valve in the line to containment. The valve, unfortunately, reseated in the closed position when it was opened with a -14 kPa(g) pressure drop across it. The air samples at the three remaining sites were collected in the Tedlar bags as planned.

The concentration of ethylene tracer gas in the boiler rooms prior to the inleakage test was found to be below detection (<5 ppb). After the outage in May, 1987, it was estimated that about 15 ppm ethylene remained in containment. The containment background samples taken prior to the inleakage test indicated only a trace amount of ethylene (5 ppb) remaining in containment.

The average ethylene concentration in the Unit 2 boiler rooms during the experiment is shown in Figure 3. The concentration of ethylene in the two boiler rooms was maintained between 8 and 12 ppm over the last hour and a half of the three hour test period. During the first hour of the test period an accurately measurable ethylene background was established within containment. For the remaining 2 h of the test, measurement of the increase above this background allowed the inleakage rate (%/h) from the boiler rooms to be estimated. The pressure in containment was maintained at about -14 kPa(g) with a variance of about 0.25 kPa(g) over the three hour test period. Figure 4 displays the pressure trends during the test.

The ethylene concentrations determined from samples collected at external penetration EP-1057 are shown in Figure 5. The region over which the inleakage rate was determined is enclosed within the dashed lines on Figures 3, 4 and 5.

The estimated volume of the two boiler rooms is about 1750 m³ and the volume of Unit 2 containment is estimated to be about 11,800 m³. An inleakage rate was estimated during the second half of the three hour experiment as the containment ethylene concentrations were measured with good accuracy and the boiler room ethylene concentrations were relatively constant. From Figure 3 the estimated ethylene concentration in the boiler rooms was about 11.0 ppm $\pm$ 1.0 ppm for the inleakage calculation period (13:45 to 14:50).

TABLE I
ETHYLENE TRACER GAS INLEAKAGE FROM UNIT 2
BOILER ROOMS DURING QUARTERLY LEAKRATE TEST

Sample Number	Time Taken (hh:mm)	Ethylene Concentrations			External Penetration EP-1057 (ppb)
		East Boiler Room	West Boiler Room	Avg (ppm)	
1	12:45	15.0	8.0	12.5	7.4
2	12:50				7.1
3	12:55	6.5	6.8	6.6	9.1
4	13:00				7.6
5	13:05	4.8	6.5	5.6	8.8
6	13:10				9.8
7	13:15	4.2	2.5	3.4	9.6
8	13:20				8.3
9	13:25	4.0	na	2.0	8.8
10	13:30				11.8
11	13:35	4.0	na	2.0	9.8
12	13:40				11.5
13	13:45	8.5	8.6	8.6	11.3
14	13:50				11.3
15	13:55	8.6	13.0	10.8	na
16	14:00				14.2*
17	14:05	8.6	13.0	10.8	11.8
18	14:10				13.7
19	14:15	10.0	12.6	11.3	14.2
20	14:20				13.2
21	14:25	10.6	na	10.6	15.2
22	14:30				14.7
23	14:35	10.2	14.7	12.5	18.1
24	14:40				19.1
25	14:45	11.8	13.5	12.6	22.5
26	14:50				23.0
27	14:55	12.2	6.8	9.5	18.7
28	15:00				19.1
29	15:05	12.2	5.0	8.6	20.6
30	15:10				22.5
32	15:15	11.5	4.5	8.0	24.5
33	15:20				19.6

na - not available (sample lost or unreliable)

* - sample very noisy so result may be suspect

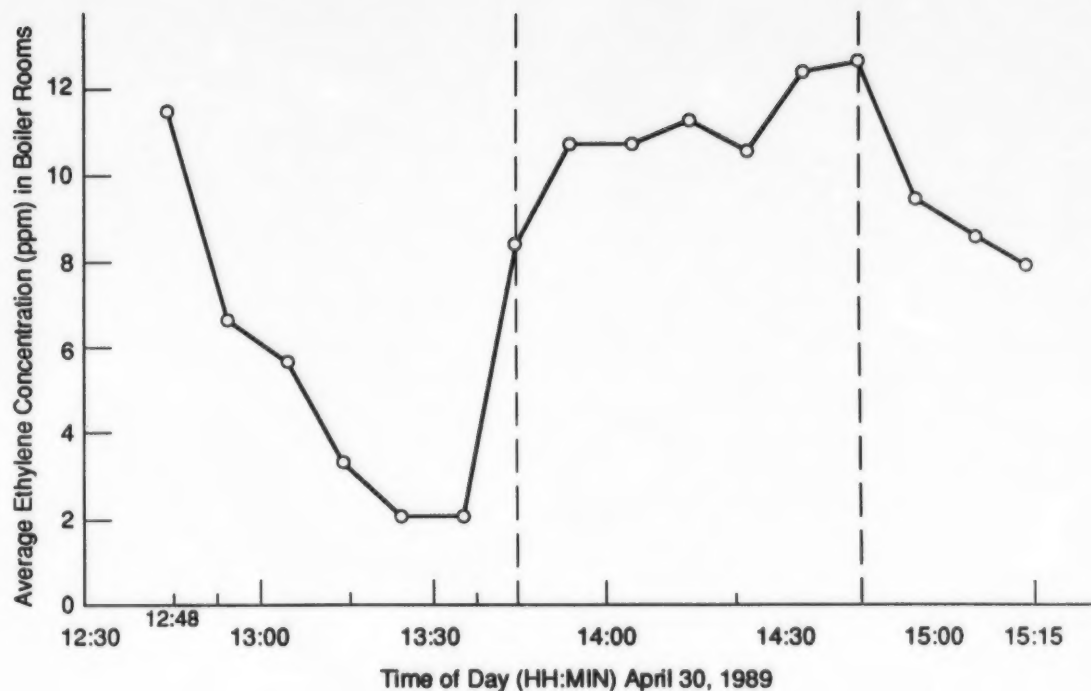


FIGURE 3
AVERAGE CONCENTRATION OF ETHYLENE IN UNIT 2 BOILER ROOMS
AS A FUNCTION OF TIME OF DAY

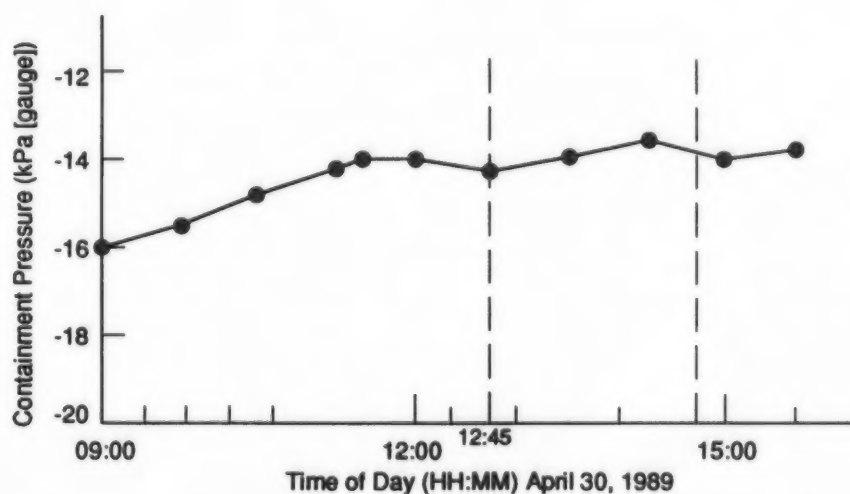


FIGURE 4
CONTAINMENT NEGATIVE PRESSURE (kPa [GAUGE])
AS A FUNCTION OF TIME OF DAY (APRIL 30, 1989)

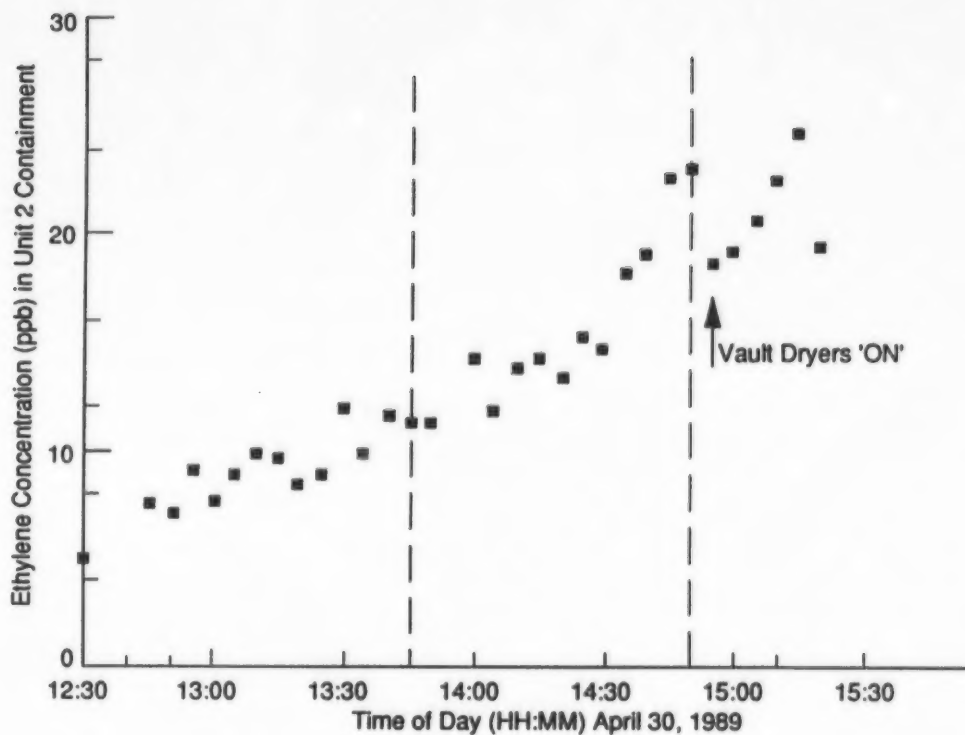


FIGURE 5
ETHYLENE TRACER GAS CONCENTRATIONS IN UNIT 2 CONTAINMENT
AS A FUNCTION OF TIME OF DAY

The calculated rate of increase in the ethylene concentration in containment over the same period was $0.24 \text{ ppb min}^{-1}$ (14.6 ppb h^{-1}). This translated into an inleakage rate of about 0.9% of the boiler room volume per hour.

The Bruce NGS 'A' containment leakrate at about 15 kPa(g) is about $660 \text{ kg(air) h}^{-1}$ /3/. This corresponds to about $560 \text{ m}^3 \text{ h}^{-1}$ of dry air at 25°C. The contribution of the Unit boiler rooms to this leak-rate is approximately 2.8% of the total leakage.

4.0 CONCLUSIONS AND RECOMMENDATIONS

From the single inleakage test performed at Bruce NGS 'A' Unit 2 boiler rooms it can be concluded that at the relatively steady negative pressure of about -14 kPa(g) (2.0 psig) there definitely is leakage from the Unit 2 boiler rooms into containment. The rate is estimated to be about 0.9% of the boiler room volume per hour (about $15.7 \text{ m}^3 \text{ h}^{-1}$).

The inleakage from the Unit 2 boiler rooms is not as large a contributor to the overall leak rate for Bruce NGS 'A' containment as was previously thought. This fact was confirmed during the Bruce NGS 'A' 1989 outage and pressure test /4/ where only low concentrations of tracer gas were detected in the boiler rooms for all the Units at 15 kPa(g) and at 82 kPa(g) containment test pressures.

The repair procedures performed in the Unit 2 boilers after the results of the 1987 outage were done effectively.

It is recommended that additional tracer gas sampling points into containment be made available for future containment inleakage experiments. It is also recommended that the grab sampling frequency at each measurement location be increased and that the tracer gas injection be controlled through the use of mass flow controllers. The additional sampling locations, and the increased sampling frequency and the steady tracer gas injection would improve the accuracy and confidence of the inleakage rate determination.

ACKNOWLEDGEMENT

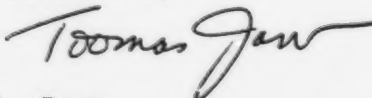
Mr. Brian Handy calibrated the instrumentation and performed the sample analysis.

Approved by:



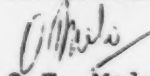
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